COST OF EMERGENCY PUMPING AT GRINNELL, IOWA[1]

By William G. Raymond

The city of Grinnell, Iowa, has a municipal water plant consisting of certain deep wells, cisterns into which the water is pumped from these wells, and a standpipe and distribution system. Formerly the city owned and operated its own pumping plant but in the early part of 1916 it entered into a contract with the Iowa Light, Heat, & Power Company, a company supplying electric light and power and steam heat in the city of Grinnell, to take over the city's pumping operations. The power plant adjoins the site of the wells and standpipe.

The pumping done by the city had been by means of an air lift from the wells into cisterns and with pressure pumps into the distribution system. The power company, on taking over the contract, believing from representations made to it by a deep-well concern that it could operate with greater efficiency by the use of motor-driven deep-well pumps for lifting the water from the wells into the cistern than it could by operating the air compressors, installed two deep-well pumps in the two wells of the city and began operations.

The contract price for pumping was $9\frac{1}{2}$ cents a thousand gallons, the water being measured by the city's meter on the main at the beginning of the distribution system.

The deep-well pumps were installed in the fall of 1916 and continued in operation until early in 1918, when one of the wells got out of repair, rendering pumping from it impossible. The remaining pump was unequal to supplying the demand from the one well, and at the suggestion of the city the company installed one of the city's old air compressors in its plant and undertook to lift water from the one remaining well by the air-lift method. It was successful in doing this and was able to furnish an adequate supply, but it complained that the cost of pumping was much increased and asked the city for relief, and an understanding was entered into that

[1] Read before the annual meeting of the Iowa Section on April 17, 1919.

pending the sinking of another well and the return to normal conditions of pumping, the city would pay the actual cost of pumping.

Thereafter, following March, 1918, the company billed to the city monthly what it determined to be its several items of cost. As a result of an experiment made with one of the air compressors hooked up to be driven by a motor, the company estimated that 6 kilowatt-hours were required to lift 1000 gallons of water from the well into the cistern. As a result of a report by the Krehbiel Company, the power was estimated to cost varying sums, depending on the cost of coal, ranging from 2.9 to 3 cents. The company had installed a triplex power pump, motor driven, for forcing water from the cisterns into the mains, and the motor driving this pump was metered so that the quantity of power was known. In addition to the cost of power for lifting the water from the wells and forcing it into the mains, certain charges for oil and labor used exclusively in connection with the pumping were made; and as a result of all these charges, including depreciation on the unused pumping plant, the pumping was billed during the following months at costs which made the cost per thousand gallons vary approximately from 22 to 24 cents.

The Iowa Light, Heat & Power Company, in the fall of 1918 appealed to the Iowa State Board of Conciliation for higher rates for electric service in the city of Grinnell and for adjudication of the water pumping costs which had been objected to by the city as too high. The city and the company both appeared before the Board of Conciliation at a hearing in October, and both parties to the controversy seemed inclined to do the fair thing if that could be discovered. The city, however, had very few data to present tending in any way to disprove the claims made by the company and the Board of Conciliation, after granting a certain small increase in rates for lighting and power, felt compelled to recommend a cost of 22 cents per thousand gallons for pumping in spite of the fact that this appeared to be an exorbitant price. At the same time it informally recommended to the city that a more careful investigation be made of the actual cost, as it appeared to all the members of the Board that some discrepancy must have crept in to affect the results of the experiment made by the power company to determine cost.

Accordingly, the city of Grinnell engaged the author to make an investigation of the cost of pumping, which he did in January, 1919, the

actual measurements in the test being made under the direction of and by Professor George J. Keller, acting head of the Department of Mechanical Engineering in the State University of Iowa. As the rate was to be temporary pending the putting into use of the new well, it was thought to be undesirable to go to the expense of making a complete valuation of that part of the company's property which was in any way concerned with the pumping operations, and as the plant is practically new, the company's statement of costs of plant and equipment was used for estimating interest and depreciation charges. The books of the company were examined to discover the cost of labor, fuel, and supplies, and the meter readings of the meter through which the company buys its water for steam making were taken as indicating the quantity of steam produced. Of course there is a slight error here, but it is insignificant and it was thought that the readings extending over a year would be of more value than the results of a single test which would be costly to make.

It was thought that the great discrepancy, if any, lay in the determination of the amount of power used in lifting the water by the air lift from the well into the cistern. The method of test here was to measure the steam flow to the compressor by means of a flow meter and to measure the water pumped into the cistern during the period of steam measurement. This required the shutting down of the power pumps during this same period and the calibration of the cisterns. As a result of this test it was found that the compressor used not to exceed 3040 pounds of steam per hour and that this quantity of steam used resulted in the lifting of 12,210 gallons of water or approximately 249 pounds of steam per 1000 gallons of water. It remained, then, to find the cost of the steam, to which would be added the cost of such labor and supplies as pertained exclusively to the pumping system, and the cost of the power pumping.

As the figures for quantity of water pumped, coal consumed, etc., were given in the records by the month and as the period of operation during 1918 was nine months, the amount of steam consumed had to be determined by estimating the number of gallons pumped during the nine months; and this could be done only by using the meter records of the city's meter at the beginning of the distribution system. It was claimed by the company, and, after a test, admitted by the city, that this meter had run slow by varying amounts, which for the purpose of the computation it was agreed had averaged about 15 per cent, so that the sum of the meter readings was assumed to

indicate 85 per cent of the water pumped. Using the 249 pounds of steam per thousand gallons lifted and the correct amount of water pumped during the nine months, the consumption of steam for the whole period by the air compressor was obtained. The remainder of the steam generated was charged to power production as one of the elements in obtaining the cost per kilowatt-hour of generating power. The details of this process need not be given but it may be mentioned that interest at 6 per cent on all of that part of the plant concerned with steam making was allowed in determining the cost of steam, and 6 per cent on the cost of the entire plant was allowed in estimating the cost of generating power. Depreciation also was estimated on the depreciable parts of the property by the compound interest method at the 6 per cent rate, as it was understood that the company carries a depreciation reserve. The net profits from steam heating as stated by the company were used as profits arising from a by-product reducing the cost of steam and power. As a result of the entire computation the following was found:

The cost for power was $0.02977 per kilowatt-hour.

The amount of power used for power pumping was 0.46 kilowatt-hour per 1000 gallons, giving the cost of power pumping for power alone $0.01369 per 1000 gallons.

Interest and depreciation and plant labor and supplies, chargeable directly and only to pumping operations amount to $0.02760 per 1000 gallons.

The air pumping, exclusive of the interest and depreciation, plant labor and supplies, chargeable only to pumping operations, appeared to be as follows:

	per 1000 gallons
Fuel	$0.084949
Labor	$0.01377
Water	$0.00239
Station maintenance	$0.00896
Interest and depreciation	$0.01405
Total	$0.12411
Credit for steam heating	$0.01013
Balance	$0.11398

Against the total cost, an allowance of 0.3 cent was made on account of accrued depreciation, and the total cost per thousand gallons for pumping was thus found to be:

	per 1000 gallons
Steam for air pumping	$0.11398
Power for power pumping	$0.01369
Special labor, supplies, interest and depreciation	$0.02760
Total	$0.15537
Less for depreciated plant	$0.00300
Net total cost of pumping	$0.15237

Settlement was made by the city on this basis.

The well referred to in the foregoing is about 2000 feet deep, cased with 7-inch pipe for 320 feet and with 5-inch pipe to a depth of about 1460 feet, below which the well is in limestone and sandstone. The air lift is of the simplest type, a $1\frac{1}{2}$-inch air pipe extending down 650 feet into the well, the water standing at 260 feet below the surface when there is no pumping. It is not known how much it is drawn down during pumping.

The air compressor was an old simple steam, compound air Ingersoll, with poor valve settings at the time the test was made, with 12 by 12 inch steam cylinders and 10 by $16\frac{3}{4}$-inch air cylinders, developing 71.6 horse-power. The efficiency of the entire machine was $83\frac{1}{2}$ per cent. The air pressure developed was 145 pounds when running and 165 pounds at starting.

Coal cost almost exactly $4.00 a net ton in the yard. The total pumpage was slightly in excess of 7,000,000 gallons a month or about 235,000 gallons daily. The normal pressure of the distribution system at the plant was 40 pounds, with an increase for fire pressure.

The city saves something like $5000 a year as the result of the more careful determination.